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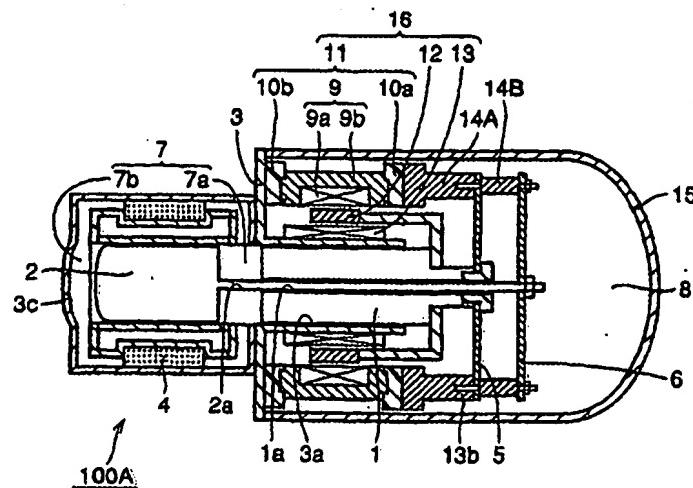
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(54) STIRLING REFRIGERATING MACHINE

(57) A Stirling refrigerator has an outer yoke assembly (11) provided as an outer yoke constituting a linear motor (16) and has a piston-support-spring support member (14A) and a displacer-support-spring support member (14B) that are supported by the outer yoke assembly (11) for fixing a piston support spring (5) and a

displacer support spring (6) respectively. By the above-described structure, it is achieved to facilitate handling, in assembly of mass production, of a bobbin/coil and an outer yoke of an outer yoke body constituting the linear motor and reduce the size of the outer shape of a casing.

FIG. 1



Description**Technical Field**

[0001] The present invention relates to a Stirling refrigerator used for generation of low temperatures and more specifically, to a structure of a linear motor for reciprocating a piston, a structure of piston elastic support means supporting the piston and a structure of displacer elastic support means supporting a displacer.

Background Art

[0002] A free-piston Stirling refrigerator for generating cold heat is also called reverse Stirling refrigerator in terms of heat cycle. This Stirling refrigerator has a structure as described below with reference to Fig. 12.

[0003] A conventional Stirling refrigerator 100E has a cylinder 3 including a linearly reciprocating piston 1 and a displacer 2. Piston 1 and displacer 2 are coaxially structured and a rod 2a formed on displacer 2 passes through a slide hole 1a provided in a central part in the axial direction of piston 1. Piston 1 and displacer 2 are provided to be smoothly slidable along an inner-periphery slide surface 3a of cylinder 3.

[0004] At an upper part (on the right side in Fig. 12) of rod 2a formed on displacer 2, respective central parts of a piston support spring 5 and a displacer support spring 6 are fixed. Piston support spring 5 and displacer support spring 6 are each in the shape of a spiral disk-like panel.

[0005] Piston 1 is elastically fixed with respect to casing 15 by piston support spring 5 supported by a support member 31 fixed to casing 15. Displacer 2 is also elastically fixed with respect to casing 15 by displacer support spring 6 supported by support member 31.

[0006] The internal space formed by cylinder 3 is divided into two spaces by piston 1. A first space is a working space 7 formed at the side of displacer 2 with respect to piston 1. A second space is a back space 8 formed at the opposite side of displacer 2 with respect to piston 1. These two spaces are filled with such a working medium as helium gas at high pressure.

[0007] A linear motor 16 includes an inner yoke 13 fixed to cylinder 3, an outer yoke body 9 formed of an outer yoke 9b placed with a predetermined gap between itself and inner yoke 13 to enclose a bobbin/coil 9a, and a permanent magnet 12 attached to piston 1 and placed in the gap between inner yoke 13 and outer yoke 9b. Outer yoke 9b is fixed to casing 15 by a positioning block 30 supported by support member 31.

[0008] Piston 1 is axially reciprocated at predetermined cycles by the action of linear motor 16. The reciprocating motion of piston 1 causes the working medium to be repeatedly compressed and expanded in working space 7. Displacer 2 is linearly reciprocated by a change in pressure of the working medium which is compressed and expanded in working space 7. Piston

1 and displacer 2 are configured to reciprocate at the same cycles with a phase difference therebetween of approximately 90°.

[0009] Working space 7 is further divided into two spaces by displacer 2. A first working space is a compression space 7a located between piston 1 and displacer 2. A second working space is an expansion space 7b at the top of cylinder 3. Compression space 7a and expansion space 7b are coupled via a regenerator 4.

[0010] Regenerator 4 is formed of a mesh-shaped copper member for example.

[0011] The working medium in expansion space 7b generates cold heat at a cold head 3c at the top of cylinder 3. Reverse Stirling heat cycle such as this principle of generation of cold heat is a well-known art and thus description thereof is not provided here.

[0012] Stirling refrigerator 100E of the above-discussed structure, however, has following problems.

[0013] First, components of coil/bobbin 9a and outer yoke 9b have low strength and thus these components must be handled carefully in assembly of mass production. Second, in the structure as shown in Fig. 12 with piston support spring 5 and displacer support spring 6 fixed to casing 15, support member 31 fixed to casing

[0014] 15 has to be extended to the positions of piston support spring 5 and displacer support spring 6, resulting in increase in size of the outer shape of casing 15 to make it necessary to increase the thickness of a material for casing 15 in terms of strength.

Disclosure of the Invention

[0015] One object of the present invention is to provide a Stirling refrigerator by which handling in assembly of mass production of a coil/bobbin and an outer yoke of an outer yoke body constituting a linear motor can be facilitated and a casing can be reduced in size of its outer shape.

[0016] A Stirling refrigerator according to the present invention includes a casing, a cylinder provided in the casing, a piston provided in the cylinder to be made movable in a reciprocating manner in the axial direction of the cylinder by a linear motor provided on an outer surface of the cylinder, and a displacer provided in the cylinder to form a compression space between itself and the piston in the cylinder and to be movable in a reciprocating manner in the axial direction. The linear motor includes an inner yoke provided on the outer surface of the cylinder, an outer yoke assembly provided to the casing to enclose the inner yoke, and a permanent magnet placed in a gap between the inner yoke and the outer yoke assembly and coupled to the piston. The outer yoke assembly includes a bobbin/coil placed to face the inner yoke, an outer yoke provided to cover the bobbin/coil from the casing and in the axial direction, and a pair of ring-shaped holding members provided to hold the outer yoke therebetween in the axial direction.

[0017] The pair of ring-shaped holding members can

thus be provided to achieve an integral structure holding, between the paired holding members, the coil/bobbin and the outer yoke of the outer yoke body which constitutes the linear motor. Accordingly, an integral strength can be obtained from the outer yoke assembly in assembly of the Stirling refrigerator to facilitate handling of the outer yoke assembly.

[0016] Preferably, according to the present invention, the Stirling refrigerator further includes piston support means for elastically supporting the piston with respect to the casing to make the piston movable in a reciprocating manner in the cylinder, and displacer support means for elastically supporting the displacer with respect to the casing to make the displacer movable in a reciprocating manner in the cylinder. The piston support means includes a first elastic member coupled to the piston and first-elastic-member support means for supporting the first elastic member and fixed to an end in the axial direction of the outer yoke assembly. The displacer support means includes a second elastic member coupled to the displacer and second-elastic-member support means for supporting the second elastic member and fixed to the end in the axial direction of the outer yoke assembly.

[0017] This structure can be employed to place the first-elastic-member support means and the second-elastic-member support means on the upper side of the linear motor and thereby reduce the size of the outer shape of the casing. Accordingly, in terms of the strength of the casing, the thickness of the casing can be reduced and thus the weight and cost of the Stirling refrigerator can be reduced.

[0018] As for the conventional structure, the support means is constituted of a long member passing along the side of the linear motor, resulting in accidental deformation of the long member in assembly of the Stirling refrigerator to make it difficult to define the center of axis of each component. According to the present invention, such a situation can be avoided.

[0019] Still preferably, according to the present invention, the first elastic member and the second elastic member are substantially disk-shaped, and the first elastic member has an outer diameter smaller than that of the second elastic member and the first-elastic-member support means is placed at a height lower than that of second-elastic-member support means.

[0020] This structure can be employed to prevent one of respective fastening parts at which the first-elastic-member support means and the second-elastic-member support means are respectively fastened from influencing the other fastening part. In other words, as these components are independently fixed to the elastic member support means, the elastic members never come apart and thus the Stirling refrigerator can be improved in its reliability.

[0021] Still preferably, according to the present invention, the first-elastic-member support means and the second-elastic-member support means are provided at

a ring-shaped base plate. Still more preferably, according to the present invention, the first-elastic-member support means and the second-elastic-member support means are post-shaped. This structure can be employed to improve the working efficiency in attachment of the first elastic member and the second elastic member each.

[0022] Still preferably, according to the present invention, one holding member of the paired holding members is provided integrally with the ring-shaped base plate. This structure can be employed to reduce the number of components.

Brief Description of the Drawings

[0023]

Fig. 1 is a cross-sectional view showing an entire structure of a Stirling refrigerator 100A according to a first embodiment.

Figs. 2A and 2B are first drawings showing a structure of an outer yoke body 9.

Figs. 3A and 3B are second drawings showing the structure of outer yoke body 9.

Figs. 4A and 4B show a structure of an outer yoke assembly 11 and assembling thereof.

Figs. 5A and 5B show a structure of a piston-support-spring support member 14A.

Fig. 6 is a cross-sectional view showing an entire structure of a Stirling refrigerator 100B according to a second embodiment.

Figs. 7A and 7B show a structure of a piston-support-spring support member 14C.

Fig. 8 is a cross-sectional view showing an entire structure of a Stirling refrigerator 100C according to a third embodiment.

Figs. 9A and 9B show a structure of a piston-support-spring support member 14D.

Fig. 10 is a cross-sectional view showing an entire structure of a Stirling refrigerator 100D according to a fourth embodiment.

Figs. 11A and 11B show a structure of a piston-support-spring support member 14E.

Fig. 12 is a cross-sectional view schematically showing a structure of a Stirling refrigerator according to a conventional art.

Best Modes for Carrying Out the Invention

[0024] A structure of a Stirling refrigerator according to each embodiment of the present invention is herein-after described with reference to the drawings. It is noted that any component which is the same as or corresponding to the component of the conventional art described in connection with Fig. 12 is denoted by the same reference numeral and description thereof is not repeated here.

(First Embodiment)

[0025] Referring to Figs. 1-5B, a structure of a Stirling refrigerator 100A according to a first embodiment is described. Fig. 1 is a cross-sectional view showing the entire structure of Stirling refrigerator 100A, Figs. 2A-4B show a structure of an outer yoke assembly 11 and assembling thereof, and Figs. 5A and 5B show a structure of a piston-support-spring support member 14A.

(Structure of Stirling Refrigerator 100A)

[0026] Referring to Fig. 1, Stirling refrigerator 100A has a basic structure which is the same as that of Stirling refrigerator 100E described in connection with Fig. 12, and a characteristic structure of Stirling refrigerator 100A in this embodiment is that an outer yoke assembly 11 is provided as an outer yoke constituting a linear motor 16 and that, for fixing a piston support spring 5 and a displacer support spring 6 as a first elastic member and a second elastic member respectively, a piston-support-spring support member 14A and a displacer-support-spring support member 14B supported by outer yoke assembly 11 are employed respectively as first-elastic-member support means and second-elastic-member support means.

(Structure of Outer Yoke Assembly 11)

[0027] A structure of outer yoke assembly 11 is described with reference to Figs. 2A-4B. Referring to Figs. 2A, 2B, 3A and 3B, an outer yoke body 9 has a bobbin/coil 9a in the shape of a ring with a copper wire wound around a bobbin, and an outer yoke 9b divided into a plurality of sections each formed of stacked steel plates for the yoke, outer yoke 9b being fixed to the outer surface of bobbin/coil 9a with an adhesive.

[0028] Figs. 2A and 2B show a state before outer yoke 9b is fit on the outer surface of ring-shaped bobbin/coil 9a, Fig. 2A showing a structure in plan view and Fig. 2B showing a cross-sectional structure along the plane indicated by arrows IIB-IIB in Fig. 2A. Figs. 3A and 3B show a state in which outer yoke 9b is fit on the outer surface of ring-shaped bobbin/coil 9a, Fig. 3A showing a structure in plan view and Fig. 3B showing a cross-sectional structure along the plane indicated by arrows IIIB-IIIB in Fig. 3A. On the upper surface and the lower surface of outer yoke 9b respectively, protrusions 90 are provided for defining positions at which an upper holding plate 10a and a lower holding plate 10b described hereinbelow are to be attached.

[0029] Referring to Figs. 4A and 4B, on the upper side and the lower side of outer yoke body 9, upper holding plate 10a and lower holding plate 10b in the shape of a ring made of a resin material having a relatively high stiffness are attached to hold outer yoke body 9 therebetween in the axial direction, and thus outer yoke assembly 11 is completed. Upper holding plate 10a and

lower holding plate 10b have respective depressions 91 in which protrusions 90 provided to outer yoke 9b are fit respectively. Fig. 4A shows a cross-sectional structure before upper holding plate 10a and lower holding plate 10b are attached to outer yoke body 9, and Fig. 4B shows a cross-sectional structure in the state in which upper holding plate 10a and lower holding plate 10b are attached to outer yoke body 9.

[0030] Referring again to Fig. 1, outer yoke assembly 11 structured as described above is fixed with respect to cylinder 3 by using bolts (not shown) in such a manner that the center of the axis of cylinder 3 and that of outer yoke assembly 11 match each other. In order to allow the axis center of cylinder 3 and that of outer yoke assembly 11 to match each other, a jig (not shown) is used.

(Structure of Piston-Support-Spring Support Member 14A and Displacer-Support-Spring Support Member 14B)

[0031] Referring to Figs. 5A and 5B, a structure of piston-support-spring support member 14A is described. Fig. 5A shows a structure in plan view and Fig. 5B shows a cross-sectional structure along the plane indicated by arrows VB-VB in Fig. 5A. Piston-support-spring support member 14A is made of a brass or resin material for example and includes a base portion 140 formed of a ring-shaped base plate and a support portion 141 supporting piston support spring 5. Support portion 141 has a plurality of screw holes B1 for fastening piston support spring 5 and displacer-support-spring support member 14B described hereinbelow.

[0032] As shown in Fig. 1, displacer-support-spring support member 14B is in the shape of a ring having a uniform thickness and made of a brass or resin material for example similarly to piston-support-spring support member 14A.

[0033] Piston-support-spring support member 14A is fixed with respect to upper holding plate 10a of outer yoke assembly 11 with bolts (not shown). For positioning of piston-support-spring support member 14A with respect to upper holding plate 10a, a jig (not shown) is used. Displacer-support-spring support member 14B is also fixed with respect to piston-support-spring support member 14A with bolts.

(Function and Effect)

[0034] The Stirling refrigerator according to this embodiment employs an integral structure of outer yoke assembly 11 constituting linear motor 16 and having coil/bobbin 9a and outer yoke 9b that are held between upper holding plate 10a and lower holding plate 10b to obtain an integral strength from outer yoke assembly 11 and facilitate handling of outer yoke assembly 11.

[0035] In attachment of outer yoke assembly 11 to cylinder 3, outer yoke assembly 11 is surely positioned with respect to cylinder 3 to make it possible to simultane-

ously position coil/bobbin 9a, outer yoke 9b, piston-support-spring support member 14A and displacer-support-spring support member 14B with respect to cylinder 3 and accordingly shorten the cycle time for manufacturing the Stirling refrigerator.

[0036] Piston-support-spring support member 14A and displacer-support-spring support member 14B are placed at the upper part corresponding to an end in the axial direction of linear motor 16 and thus the size of the outer shape of casing 15 can be reduced. Accordingly, casing 15 can be reduced in thickness in terms of the strength of casing 15 and thus the Stirling refrigerator can be reduced in weight as well as cost.

[0037] In addition, while the support member of the conventional structure is constituted of a long member passing along the side of linear motor 16, resulting in accidental deformation of the long member in assembly of the Stirling refrigerator to make it difficult to define the center of the axis of each component, such a situation can be avoided here.

(Second Embodiment)

[0038] Referring to Figs. 6, 7A and 7B, a structure of a Stirling refrigerator 100B according to a second embodiment is described. Fig. 6 is a cross-sectional view showing the entire structure of Stirling refrigerator 100B, and Figs. 7A and 7B show a structure of a support-spring support member 14C.

(Structure of Stirling Refrigerator 100B)

[0039] As compared with the structure of Stirling refrigerator 100A in the first embodiment discussed above, Stirling refrigerator 100B of the second embodiment includes a support-spring support member 14C instead of piston-support-spring support member 14A and displacer-support-spring support member 14B. An outer yoke assembly 11 in this embodiment has the same structure as that of the Stirling refrigerator 100A in the first embodiment.

(Structure of Support-Spring Support Member 14C)

[0040] According to this embodiment, a piston support spring 5 and a displacer support spring 6 have different outer shapes respectively, and support-spring support member 14C supports both of piston support spring 5 and displacer support spring 6. Referring to Figs. 7A and 7B, support-spring support member 14C has a structure as described below. Fig. 7A shows a structure in plan view and Fig. 7B shows a cross-sectional structure along the plane indicated by arrows VI-VIIB in Fig. 7A. Support-spring support member 14C has a base portion 140 formed of a ring-shaped base plate, as well as a support portion 141 supporting piston support spring 5 and a support portion 142 supporting displacer support spring 6 having respective outer

shapes different from each other and being attached at different heights respectively. Support-spring support member 14C is made of a brass or resin member for example. Further, support portions 141 and 142 have a plurality of screw holes B1 for fixing piston support spring 5 and displacer support spring 6.

(Function and Effect)

[0041] The Stirling refrigerator of the second embodiment also achieves the function and effect similar to those of the first embodiment as discussed above. Moreover, piston support spring 5 and displacer support spring 6 are formed differently in outer shape and are fixed at different positions and accordingly, it never occurs that one of the fastening parts at which piston support spring 5 and displacer support spring 6 are respectively fastened influences the other fastening part.

(Third Embodiment)

[0042] Referring to Figs. 8, 9A and 9B, a Stirling refrigerator 100C of a third embodiment has a structure as described below. Fig. 8 is a cross-sectional view showing the entire structure of Stirling refrigerator 100C and Figs. 9A and 9B show a structure of a support-spring support member 14D.

(Structure of Stirling Refrigerator 100C)

[0043] As compared with the structure of Stirling refrigerator 100B of the second embodiment discussed above, support-spring support member 14D of Stirling refrigerator 100C of the third embodiment has post-shaped support portions for supporting a piston support spring 5 and a displacer support spring 6. An outer yoke assembly 11 here has the same structure as that of Stirling refrigerator 100A of the first embodiment.

(Structure of Support-Spring Support Member 14D)

[0044] Referring to Figs. 9A and 9B, support-spring support member 14D has a structure as described below. Fig. 9A shows a structure in plan view and Fig. 9B shows a cross-sectional structure along the plane indicated by arrows IXB-IXB in Fig. 9A. According to the third embodiment, as compared with support-spring support member 14C of the above-discussed second embodiment, support portions 141 and 142 for piston support spring 5 and displacer support spring 6 are provided at post-shaped portions 143 and post-shaped portions 143 are provided at four places at 90°-pitches. It is noted that the number and placement of post-shaped portions 143 are not limited to those of the third embodiment and are appropriately selected in terms of design on the condition that piston support spring 5 and displacer support spring 6 can be supported in a stable state.

(Function and Effect)

[0045] The Stirling refrigerator according to the third embodiment also achieves the function and effect similar to those of the first and second embodiments discussed above. Moreover, as support portions 141 and 142 are provided at post-shaped portions 143, working efficiency in attachment of piston support spring 5 and displacer support spring 6 can be improved. Further, the Stirling refrigerator can be reduced in weight.

(Fourth Embodiment)

[0046] Referring to Figs. 10, 11A and 11B, a Stirling refrigerator 100D of a fourth embodiment has a structure as described below. Fig. 10 is a cross-sectional view showing the entire structure of Stirling refrigerator 100D and Fig. 11 shows a structure of a support-spring support member 14E.

(Structure of Stirling Refrigerator 100D)

[0047] As compared with the structure of Stirling refrigerator 100C of the third embodiment discussed above, Stirling refrigerator 100D of the fourth embodiment similarly has post-shaped support portions for supporting a piston support spring 5 and a displacer support spring 6, while an upper holding plate 10a constituting an outer yoke assembly 11 is formed at a base 140 formed of a ring-shaped base plate.

(Structure of Support-Spring Support Member 14E)

[0048] Referring to Figs. 11A and 11B, support-spring support member 14E has a structure as described below. Fig. 11A shows a structure in plan view and Fig. 11B shows a cross-sectional structure along the plane indicated by arrows X1B-X1B in Fig. 11A. According to the fourth embodiment, as compared with support-spring support member 14D of the above-discussed third embodiment, a base 140 further serves as upper holding plate 10a constituting outer yoke assembly 11 by forming a depression 91 in which a protrusion 80 provided to an outer yoke 9b is fit, integrally with base 140.

(Function and Effect)

[0049] The Stirling refrigerator of the fourth embodiment also achieves the function and effect similar to those of the first to third embodiments discussed above. Moreover, by employing the integral structure in which upper holding plate 10a is integrally formed with support-spring support member 14E, the number of components can be reduced.

[0050] The embodiments disclosed above should be taken by way of illustration and example and not by way of limitation in terms of every respect. The scope of the present invention is defined not in the description above

but in the appended claims and it is intended that the same includes all of modifications and variations equivalent in the meaning and within the scope of the invention.

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Industrial Applicability

[0051] The Stirling refrigerator according to the present invention has a pair of ring-shaped holding members to achieve an integral structure having the coil/bobbin and the outer yoke of the outer yoke body constituting a linear motor that are held between the holding members. Accordingly, in assembly of the Stirling refrigerator, the integral strength can be obtained from the outer yoke assembly to facilitate handling of the outer yoke assembly.

[0052] Moreover, the first-elastic-member support means and the second-elastic-member support means can be placed at an upper part of the linear motor to reduce the size of the outer shape of the casing. In terms of the strength of the casing, the thickness of the casing can thus be reduced and the Stirling refrigerator can be reduced in weight and cost.

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Claims

1. A Stirling refrigerator comprising:

- 30 a casing (15);
a cylinder (3) provided in said casing (15);
a piston (1) provided in said cylinder (3) to be
made movable in a reciprocating manner in the
axial direction of said cylinder (3) by a linear
motor (16) provided on an outer surface of said
cylinder (3); and
35 a displacer (2) provided in said cylinder (3) to
form a compression space between itself and
said piston (1) in said cylinder (3) and to be
movable in a reciprocating manner in the axial
direction,
40 said linear motor (16) including
an inner yoke (13) provided on the outer sur-
face of said cylinder (3),
45 an outer yoke assembly (9) provided to said
casing (15) to enclose said inner yoke (13), and
a permanent magnet (12) placed in a gap be-
tween said inner yoke (13) and said outer yoke
assembly (9) and coupled to said piston (1),
and
50 said outer yoke assembly (9) including
a bobbin/coil (9a) placed to face said inner yoke
(13),
55 an outer yoke (9b) provided to cover said bob-
bin/coil (9a) from said casing and in the axial
direction, and
a pair of ring-shaped holding members (10a
10b) provided to hold said outer yoke (9b) ther-

ebetween in the axial direction.

2. The Stirling refrigerator according to claim 1, further comprising:

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piston support means (5, 14A) for elastically supporting said piston (1) with respect to said casing (15) to make said piston (1) movable in a reciprocating manner in said cylinder (3); and displacer support means (6, 14B) for elastically supporting said displacer (2) with respect to said casing (15) to make said displacer (2) movable in a reciprocating manner in said cylinder (3), wherein

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said piston support means (5, 14A) includes

a first elastic member (5) coupled to said piston (1), and
first-elastic-member support means (14A) for supporting said first elastic member (5) and fixed to an end in the axial direction of said outer yoke assembly (9), and

20

said displacer support means (6, 14B) includes

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a second elastic member (6) coupled to said displacer (2), and
second-elastic-member support means (14B) for supporting said second elastic member (6) and fixed to the end in the axial direction of said outer yoke assembly (9).

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3. The Stirling refrigerator according to claim 2, wherein

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said first elastic member (5) and said second elastic member (6) are substantially disk-shaped, and said first elastic member (5) has an outer diameter smaller than that of said second elastic member (6) and said first-elastic-member support means (14A) is placed at a height lower than that of said second-elastic-member support means (14B).

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4. The Stirling refrigerator according to claim 3, wherein

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said first-elastic-member support means (14A) and said second-elastic-member support means (14B) are provided at a ring-shaped base plate (140).

5. The Stirling refrigerator according to claim 4, wherein

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said first-elastic-member support means (14A) and said second-elastic-member support means (14B) are post-shaped.

6. The Stirling refrigerator according to claim 4, wherein

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one holding member (10a) of said paired holding

members (10a, 10b) is provided integrally with said ring-shaped base plate (140).

FIG.1

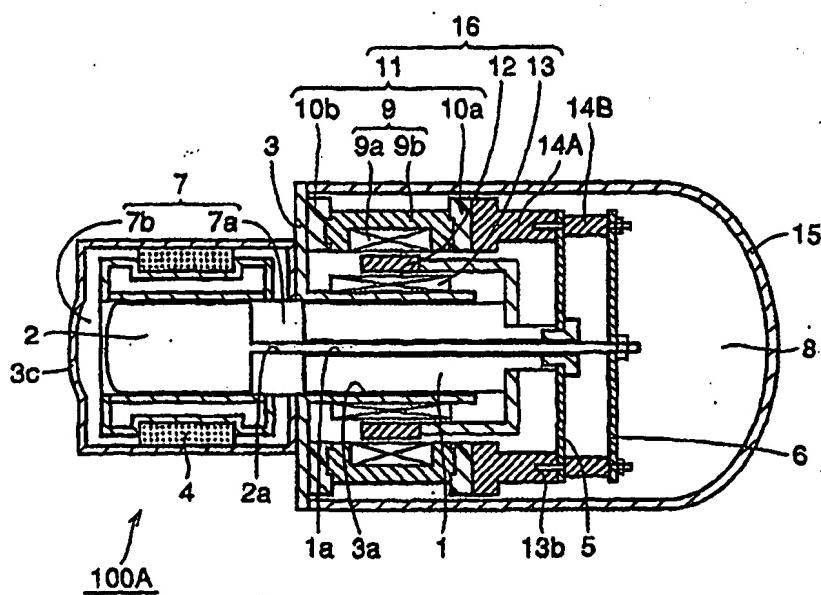


FIG.2A

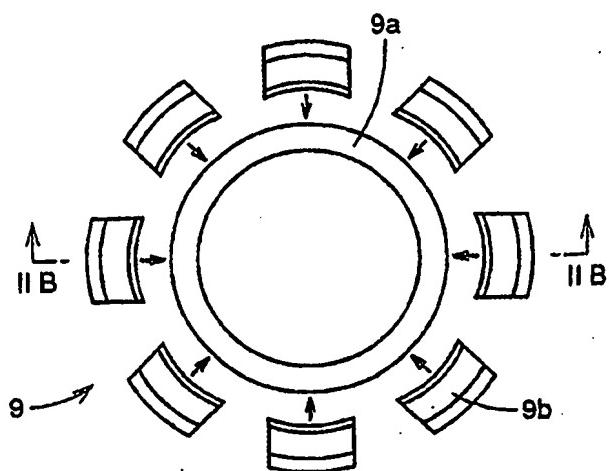


FIG.2B

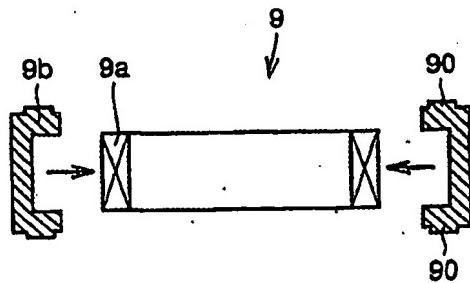


FIG.3A

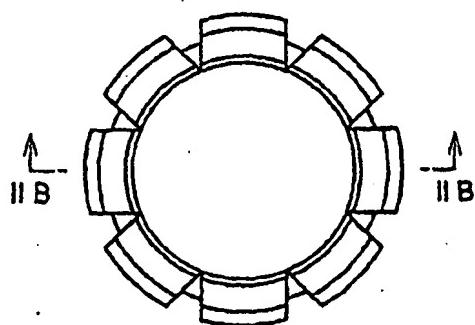


FIG.3B

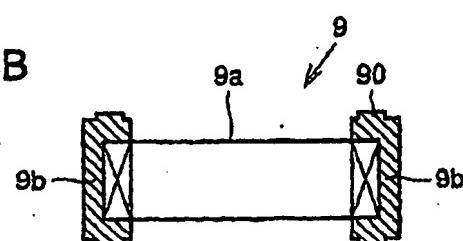


FIG.4A

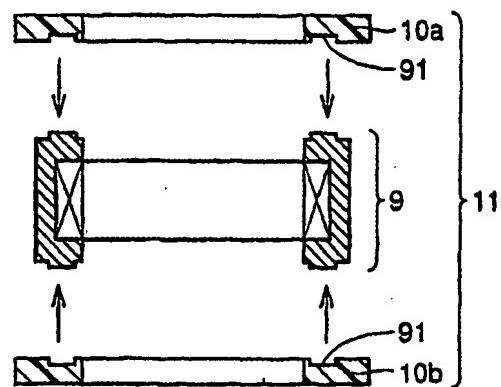


FIG.4B

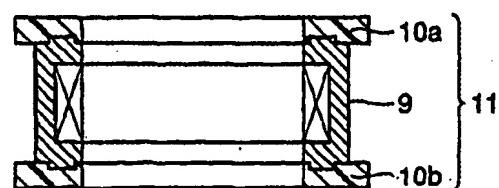


FIG.5A

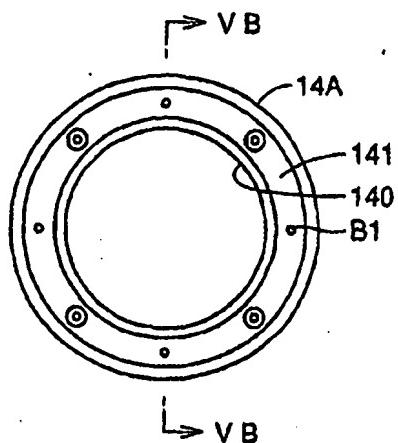


FIG.5B

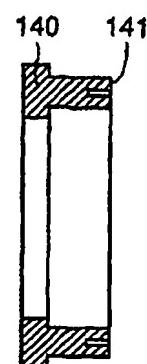


FIG.6

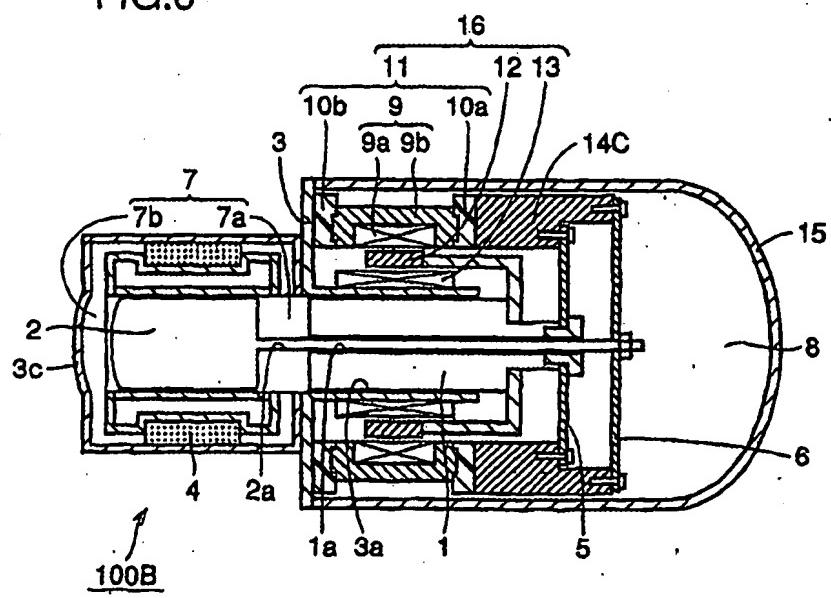


FIG.7A

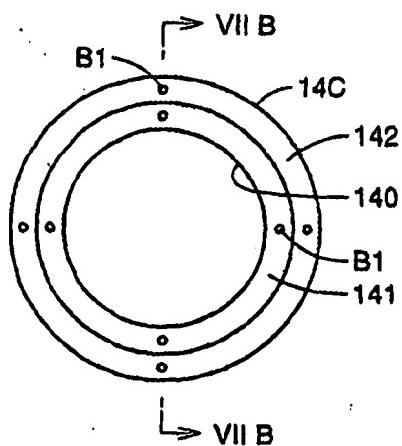


FIG.7B

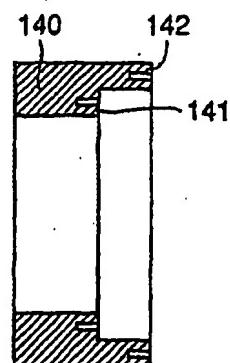


FIG.8

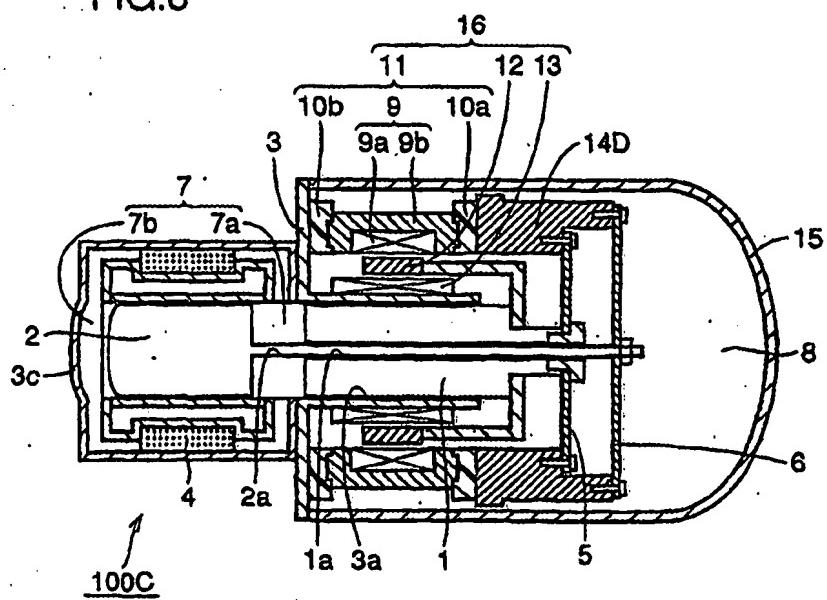


FIG.9A

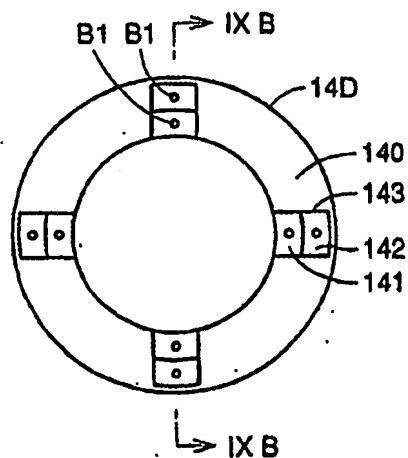


FIG.9B

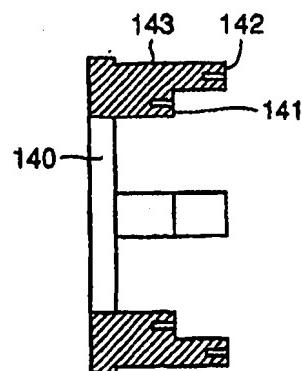


FIG.10

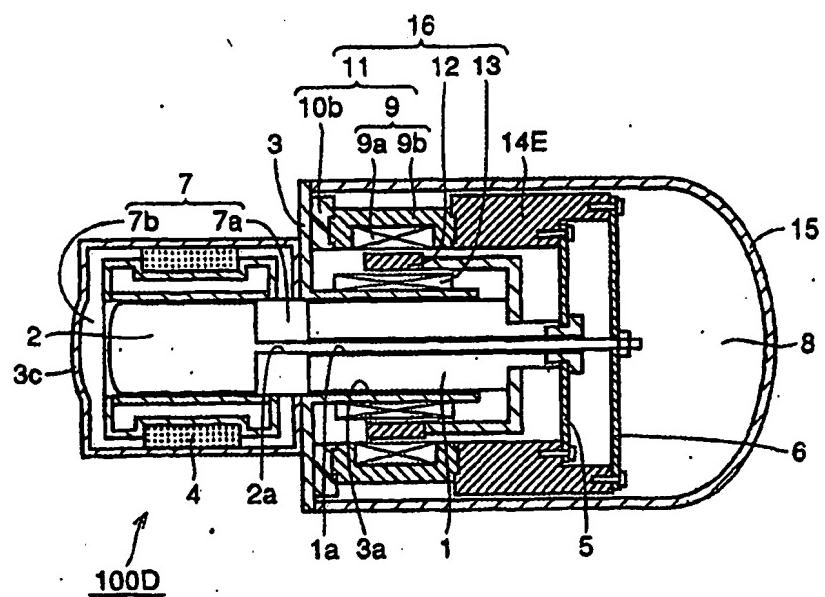


FIG.11A

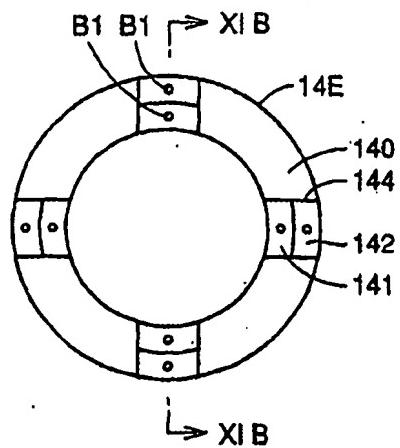


FIG.11B

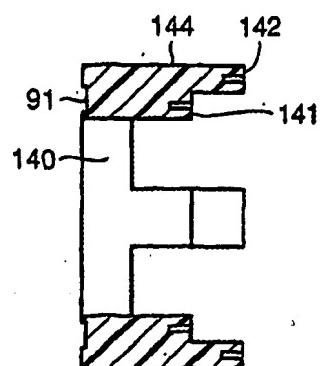
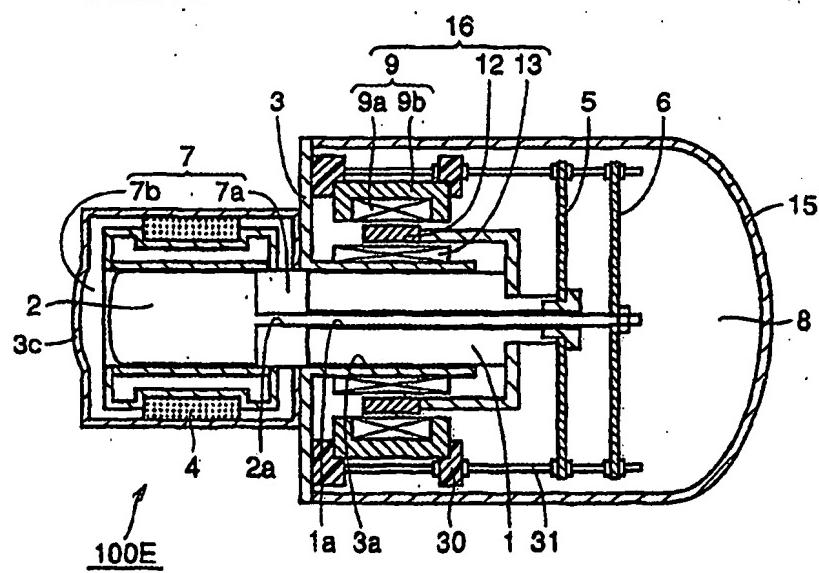


FIG.12



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP01/09527

A. CLASSIFICATION OF SUBJECT MATTER Int. Cl' P25B 9/14		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) Int. Cl' P25B 9/14		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1926-1996 Jitsuyo Shinan Toroku Koho 1996-2002 Kokai Jitsuyo Shinan Koho 1971-2002 Toroku Jitsuyo Shinan Koho 1994-2002		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 4-347460 A (Daikin Industries, Ltd.), 02 December, 1992 (02.12.1992), Column 8, line 14 to Column 9, line 20. (Family: none)	1-6
A	JP 10-197081 A (Mitsubishi Electric Corporation), 31 July, 1998 (31.07.1998), Column 4, line 16 to Column 5, line 13 (Family: none)	1-6
A	JP 2000-274854 A (Twin Bird Kogyo K.K.), 06 October, 2000 (06.10.2000) (Family: none)	1-6
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
A	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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C	document which may throw doubt on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	V* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
D	document published prior to the international filing date but later than the priority date claimed	&* document member of the same patent family
Date of the actual completion of the international search 09 January, 2002 (09.01.02)		Date of mailing of the international search report 22 January, 2002 (22.01.02)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

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